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Putting physiology into the carbon isotopic record of the Phanerozoic

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The biological process of oxygenic photosynthesis, the fixation of oxidized carbon in the form of CO_2 to reduced organic carbon, leads to an inevitable increase in the O_2/CO_2 ratio of the environment, as long as some of that reduced organic carbon is preserved in the rock record. But an increase in the O_2/CO_2 of the environment acts as a negative feedback on the process of photosynthesis and carbon fixation since the active site of the enzyme responsible for carbon fixation, Rubisco, displays competitive binding between oxygen and carbon dioxide[1]. As such, Rubisco has effectively catalysed its own challenge through geological time. In order for carbon fixation to persist after periods of organic carbon burial, either Rubisco selectivity for the competitive substrates had to improve, or phytoplankton cells had to adapt by creating high intracellular CO2/O2 ratios for their compartmentalised Rubisco. Each of these evolutionary changes exerts an impact on the carbon isotopic fractionation expressed between organic matter and the carbon substrate. Yet, this carbon isotopic fractionation appears to have been almost constant at ~ 30 ‰ for the majority of the Phanerozoic, despite major changes in the dominant open ocean phytoplankton groups and the specificity of their Rubisco. It is only in the last ~ 100 million years that a decline in e_p is evident. Here, with new phytoplankton C isotopic data from calcium carbonate and organic matter[2], and from cultures and sediment, we will explore what new insights can be derived from carbon isotopic signals through time of evolving photosynthesis, carbon(ate) burial, and the stabilization (or not) of the carbon cycle.

[1] Lu, Rickaby, Payne, Prow (2024) *National Science Review* 11 (6), nwae099.

[2] Chauhan, Rickaby, (2024) *GCA* 373, 35-51